OCR A Comb Sci Physics

Topic P1: Matter

P1.1a — describe how and why the atomic model has changed over time

1. Thomson's model suggested that the atom was a sphere of positive charge with electrons embedded in it.
2. Most alpha particles passed straight through, but some were strongly deflected.
3. Rutherford's model proposed a small, dense, positively charged nucleus with electrons around it.
4. Bohr proposed that electrons occupy specific energy levels around the nucleus.
5. New experimental evidence showed that earlier atomic models were incomplete.
6. Scientists used experimental evidence and ideas from other scientists to develop improved models.

P1.1b — describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus

1. Positive.
2. Protons and neutrons.
3. Negative.
4. The nucleus is much smaller than the atom.
5. Almost all of the mass is concentrated in the nucleus.
6. An atom has equal numbers of protons and electrons, so the positive and negative charges cancel.

P1.1c — recall the typical size (order of magnitude) of atoms and small molecules

1. About 10^-10 m.
2. 10^-10 m.
3. 1 × 10^-10 m.

4. It is enormously smaller than 1 metre.
5. Metres (m), often using nanometres (nm).
6. Atoms are far smaller than the resolving power of an ordinary light microscope.

P1.1d — define density

1. Mass per unit volume.
2. kg/m^3.
3. Mass and volume.
4. Measure the object's dimensions and calculate its volume.
5. Measure the volume of water displaced.
6. 240 ÷ 80 = 3 g/cm^3.

P1.1e — explain the differences in density between the different states of matter in terms of the arrangements of the atoms and molecules

1. Particles are closely packed in a fixed arrangement.
2. Particles are close together but can move past each other.
3. Particles are far apart and move randomly.
4. The particles in a solid are much closer together.
5. Gas particles have much more space between them.
6. Particles packed more closely generally give a greater density.

P1.1f — apply the relationship between density, mass and volume to changes where mass is conserved

1. $\rho = m \div V$.
2. $m = \rho \times V$.
3. $V = m \div \rho$.
4. 2 × 50 = 100 g.
5. 300 ÷ 3 = 100 cm^3.
6. The density increases.

P1.2a — describe how mass is conserved when substances melt, freeze, evaporate, condense or sublimate

1. It stays the same.
2. It stays the same.
3. It stays the same if no material escapes.
4. It stays the same.
5. It stays the same.
6. No particles are created or destroyed; they are only rearranged.

P1.2b — describe that physical changes differ from chemical changes because the material recovers its original properties if the change is reversed

1. A physical change does not form a new substance and the original properties can be recovered.
2. A chemical change forms one or more new substances.
3. Melting ice can be reversed to form ice again.
4. Burning forms new substances.
5. The original properties are recovered.
6. The original properties are not recovered.

P1.2c — describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state

1. It increases.
2. The temperature increases.
3. It remains constant during a change of state.
4. The supplied energy increases the internal energy and causes the change of state.
5. Energy is transferred to the system.
6. The internal energy increases.

P1.2d — define the term specific heat capacity and distinguish between it and the term specific latent heat

1. The energy needed to raise the temperature of 1 kg of a material by 1°C.
2. It tells us how much energy is needed to raise the temperature of the material.
3. The energy needed to change the state of 1 kg of a material without changing its temperature.
4. The energy needed to melt 1 kg of a material.
5. The energy needed to vaporise 1 kg of a material.
6. Specific heat capacity changes temperature; specific latent heat changes state.

P1.2e — apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature change to calculate the energy change involved

1. $\Delta E = mc\Delta T$.
2. J/kg°C.

3. It doubles.
4. 2 × 4200 × 10 = 84,000 J.
5. 5000 ÷ (0.5 × 20) = 500 J/kg°C.
6. 3 × 1000 × 5 = 15,000 J.

P1.2f — apply the relationship between specific latent heat and mass to calculate the energy change involved in a change of state

1. E = ml.
2. J/kg.
3. It doubles.
4. 0.5 × 200,000 = 100,000 J.
5. 600,000 ÷ 2 = 300,000 J/kg.
6. Energy is transferred into or out of the internal energy store.

P1.2g — explain how the motion of the molecules in a gas is related both to its temperature and its pressure

1. It increases.
2. They gain kinetic energy.
3. They collide with the walls more often.
4. The pressure increases.
5. Slower molecules collide less often and with less force.
6. Faster molecules collide more often and with greater force.

P1.2h — explain the relationship between the temperature of a gas and its pressure at constant volume (qualitative only)

1. It increases.
2. It decreases.
3. The molecules move faster and collide with the walls more frequently and forcefully.
4. The molecules move more slowly and collide less frequently and forcefully.
5. The pressure increases.
6. The pressure decreases.

Topic P2: Forces

P2.1 Motion

P2.1a — describe how to measure distance and time in a range of scenarios

1. A ruler or tape measure.
2. A stopwatch or timer.
3. Metres (m).
4. Seconds (s).
5. Measure the length of the path using a tape measure or other suitable measuring device.
6. Use a stopwatch or electronic timer to measure the journey time.

P2.1b — describe how to measure distance and time and use these to calculate speed from graphs

1. Distance and time.
2. Using a ruler, tape measure or other suitable measuring device.
3. Using a stopwatch, timer or electronic timing system.
4. Speed.
5. 20 ÷ 5 = 4 m/s.
6. 60 ÷ 10 = 6 m/s.

P2.1c — make calculations using ratios and proportional reasoning to convert units and to compute rates

1. 1000 m.
2. 60 s.
3. 2500 m.
4. 3 minutes.
5. 20 m/s.
6. 150 ÷ 12 = 12.5 m/s.

P2.1d — explain the vector-scalar distinction as it applies to displacement and distance, velocity and speed

1. A scalar quantity has magnitude only.
2. A vector quantity has magnitude and direction.
3. Distance is the total path travelled; displacement is the distance in a specified direction.
4. Speed has magnitude only; velocity has magnitude and direction.
5. Displacement.
6. Velocity.

P2.1e — relate changes and differences in motion to appropriate distance-time, and velocity-time graphs; interpret lines and slopes

1. The object is stationary.

2. Constant speed.
3. A greater speed.
4. Constant velocity.
5. Positive acceleration.
6. Negative acceleration.

P2.1f — interpret enclosed areas in velocity-time graphs

1. Distance travelled.
2. Displacement.
3. Multiply velocity by time.
4. $10 \times 5 = 50$ m.
5. A greater area indicates a greater distance travelled.
6. Calculate the area of each section and add them.

P2.1g — calculate average speed for non-uniform motion

1. Motion where speed or velocity changes.
2. Average speed = total distance ÷ total time.
3. 500 m.
4. 50 s.
5. $500 \div 50 = 10$ m/s.
6. Because the speed is changing.

P2.1h — apply formulae relating distance, time and speed, for uniform motion, and for motion with uniform acceleration

1. $d = v \times t$.
2. $a = \Delta v \div t$.
3. $15 \times 8 = 120$ m.
4. $100 \div 5 = 20$ s.
5. $(30 - 10) \div 5 = 4$ m/s^2.
6. Acceleration that remains constant.

P2.2 Newton's laws

P2.2a — recall examples of ways in which objects interact

1. Electrical interaction.
2. Gravitational interaction.
3. Magnetic interaction.
4. A force from a surface acting perpendicular to the surface.
5. A force opposing relative motion between surfaces.

6. Contact interactions require touching; non-contact interactions do not.

P2.2b — describe how such examples involve interactions between pairs of objects which produce a force on each object

1. Each object exerts a force on the other.
2. Two.
3. They act in opposite directions on the two objects.
4. A gravitational force.
5. An upward normal contact force.
6. Forces arise from interactions between objects.

P2.2c — represent forces as vectors

1. An arrow showing the size and direction of a force.
2. The magnitude of the force.
3. The direction of the force.
4. All forces acting on the object, with their directions and relative sizes.
5. Draw equal-length arrows in opposite directions.
6. Zero newtons.

P2.2d — apply Newton's first law to explain the motion of an object moving with uniform velocity and also an object where the speed and/or direction change

1. The resultant force is zero.
2. The velocity remains constant.
3. The velocity changes.
4. Velocity includes direction.
5. Zero resultant force.
6. There is a non-zero resultant force.

P2.2e — use vector diagrams to illustrate resolution of forces, a net force (resultant force), and equilibrium situations

1. Splitting a force into components.
2. The overall force after combining forces.
3. A state where the resultant force is zero.
4. Draw the forces head-to-tail and find the resultant.
5. The resultant force must be zero.
6. The forces must balance in all directions.

P2.2f — describe examples of the forces acting on an isolated solid object or system

1. Weight acts downward and air resistance acts upward.
2. It increases.
3. Constant velocity when forces are balanced.
4. Zero.
5. Air resistance equals weight.
6. Driving force balances resistive forces.

P2.2g — describe, using free body diagrams, examples where two or more forces lead to a resultant force on an object

1. Add their magnitudes.
2. Subtract the smaller from the larger.
3. 4 N to the right.
4. To the right.
5. It causes the velocity to change.
6. Add the forces as vectors.

P2.2h — describe using free body force diagrams the special case of balanced forces when the resultant force is zero

1. Equal forces acting in opposite directions.
2. Zero.
3. It remains constant.
4. Yes.
5. Equal upward and downward forces.
6. Equal opposing forces in the direction of motion.

P2.2i — apply Newton's Second Law in calculations relating forces, masses and accelerations

1. F = ma.
2. Newton (N).
3. m/s^2.
4. 5 × 3 = 15 N.
5. 20 ÷ 4 = 5 m/s^2.
6. 30 ÷ 6 = 5 kg.

P2.2j — explain that inertia is a measure of how difficult it is to change the velocity of an object and that the inertial mass is defined as the ratio of force over acceleration

1. Resistance to a change in velocity.
2. It is harder to change its velocity.
3. Its mass.
4. The ratio of force to acceleration.
5. m = F ÷ a.
6. Greater mass produces less acceleration for the same force.

P2.2k — define momentum and describe examples of momentum in collisions

1. Mass × velocity.
2. p = mv.
3. kg m/s.
4. 4 × 5 = 20 kg m/s.
5. It is conserved.
6. 2 × 3 = 6 kg m/s.

P2.2l — use the relationship between work done, force, and distance moved along the line of action of the force and describe the energy transfer involved

1. W = F × d.
2. Joule (J).
3. When a force moves an object through a distance in the direction of the force.
4. 20 × 5 = 100 J.
5. Energy is transferred to the object.
6. Only movement along the line of action of the force contributes to the work done.

P2.2m — calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules

1. One joule.
2. E⍰ = mgh.
3. 2 × 10 × 5 = 100 J.
4. It increases.
5. It decreases.
6. Work done against gravity is transferred into gravitational potential energy.

P2.2n — explain, with reference to examples, the definition of power as the rate at which energy is transferred

1. The rate of energy transfer.
2. P = E ÷ t.
3. Watt (W).
4. 600 ÷ 20 = 30 W.
5. The 1000 W machine.
6. It transfers energy at a greater rate.

P2.2o — recall and apply Newton's Third Law

1. Forces occur in equal and opposite pairs.
2. Equal size and opposite direction.
3. On different objects.
4. The object attracts Earth upwards.
5. The water pushes the swimmer forwards.
6. They act on different objects.

P2.2p — explain why an object moving in a circle with a constant speed has a changing velocity

1. Velocity is speed in a specified direction.
2. Its direction.
3. Velocity includes direction.
4. Yes.
5. Tangentially to the circle.
6. Its velocity is continually changing direction.

P2.3 Forces in action

P2.3a — explain, that to stretch, bend or compress an object, more than one force has to be applied

1. Forces must act in opposite directions.
2. Opposing forces push the material together.
3. Forces act in different directions on different parts of the object.
4. It stretches.
5. Stretching a spring.
6. Bending a ruler or compressing a sponge.

P2.3b — describe the difference between elastic and plastic deformation (distortions) caused by stretching forces

1. The object returns to its original shape.
2. The object does not return to its original shape.

3. It returns to its original shape.
4. It remains permanently deformed.
5. It will not fully return to its original length.
6. Remove the force and observe whether it returns to its original shape.

P2.3c — describe the relationship between force and extension for a spring and other simple systems

1. The increase in length from its original length.
2. Extension = stretched length − original length.
3. It increases.
4. Force per unit extension, or the spring constant.
5. A straight line through the origin.
6. Check whether the graph is a straight line through the origin.

P2.3d — describe the difference between linear and non-linear relationships between force and extension

1. Force is directly proportional to extension.
2. A straight line through the origin.
3. Force is not directly proportional to extension.
4. A curved line.
5. Find where the graph stops being straight.
6. Force and extension are no longer proportional.

P2.3e — calculate a spring constant in linear cases

1. $F = k \times e$.
2. N/m.
3. It is harder to stretch.
4. $8 \div 0.04 = 200$ N/m.
5. $250 \times 0.08 = 20$ N.
6. $15 \div 100 = 0.15$ m.

P2.3f — calculate the work done in stretching

1. Work done or elastic potential energy transferred.
2. $W = \frac{1}{2} \times F \times e$.
3. It increases.
4. $\frac{1}{2} \times 10 \times 0.20 = 1$ J.
5. $\frac{1}{2} \times 0.30 \times 20 = 3$ J.
6. Elastic potential energy.

P2.3g — describe that all matter has a gravitational field that causes attraction, and the field strength is much greater for massive objects

1. A region where a mass experiences a gravitational force.
2. It attracts it.
3. Masses attract each other gravitationally.
4. Yes.
5. It is stronger.
6. Earth has much greater mass.

P2.3h — define weight, describe how it is measured and describe the relationship between the weight of an object and the gravitational field strength, g

1. The force acting on an object due to gravity.
2. A newton meter.
3. Newton (N).
4. W = m × g.
5. About 9.8 N/kg, often taken as 10 N/kg.
6. 6 × 10 = 60 N.

P2.3i — recall the acceleration in free fall

1. Falling under gravity with no other significant force.
2. About 9.8 m/s^2.
3. m/s^2.
4. Gravity.
5. It increases by about 9.8 m/s every second.
6. It would remain about 9.8 m/s^2.

Topic P3: Electricity and magnetism

P3.1 Static electricity and current

P3.1a — describe that charge is a property of all matter and that there are positive and negative charges

1. Positive and negative.
2. Zero.
3. It becomes negatively charged.
4. It becomes positively charged.

5. Positive and negative charges balance.
6. They repel.

P3.1b — describe the production of static electricity, and sparking, by rubbing surfaces, and evidence that charged objects exert forces of attraction or repulsion on one another when not in contact

1. Electrons transfer between the surfaces.
2. Electrons cannot move freely through the material.
3. They repel.
4. They attract.
5. A large potential difference causes charge to jump through the air.
6. Charges in the wall rearrange, causing attraction.

P3.1c — explain how transfer of electrons between objects can explain the phenomena of static electricity

1. Electrons.
2. It becomes negatively charged.
3. It becomes positively charged.
4. Electrons move from one material to the other.
5. Charges in the paper are rearranged, causing attraction.
6. A charged object causes the leaves to repel.

P3.1d — recall that current is a rate of flow of charge (electrons) and the conditions needed for charge to flow

1. The rate of flow of electric charge.
2. Electrons.
3. A complete circuit and a potential difference.
4. A circuit with an unbroken conducting path.
5. A cell or battery.
6. The current stops.

P3.1e — recall that current has the same value at any point in a single closed loop

1. It is the same.
2. 0.5 A.
3. Charge cannot build up at one point in a closed loop.
4. 2 A.
5. In series with the component.
6. It splits between the branches.

P3.1f — recall and use the relationship between quantity of charge, current and time

1. Q = I × t.
2. Coulomb (C).
3. Ampere (A).
4. 3 × 20 = 60 C.
5. 120 ÷ 30 = 4 A.
6. 0.5 × 120 = 60 C.

P3.2 Simple circuits

P3.2a — describe the differences between series and parallel circuits

1. Series has one path; parallel has more than one path.
2. It is the same throughout the loop.
3. It splits between branches.
4. The supply potential difference is shared.
5. The same potential difference.
6. Ammeter in series; voltmeter in parallel.

P3.2b — represent d.c. circuits with the conventions of positive and negative terminals, and the symbols that represent common circuit elements

1. They show the direction of conventional current from positive to negative.
2. A pair of unequal parallel lines.
3. A triangle pointing towards a vertical line.
4. LDR: resistor with arrows pointing towards it; NTC: resistor with a diagonal line.
5. Ammeter: circle with A; voltmeter: circle with V.
6. Standard circuit symbols for each component.

P3.2c — recall that current (I) depends on both resistance (R) and potential difference (V) and the units in which these are measured

1. Energy transferred per unit charge.
2. Volt (V).
3. Ohm (Ω).
4. Ampere (A).
5. It increases.
6. It decreases.

P3.2d — recall and apply the relationship between I, R and V and that for some resistors the value of R remains constant but that in others it can change as the current changes

1. $V = I \times R$.
2. $12 \div 4 = 3$ A.
3. $2 \times 6 = 12$ V.
4. $10 \div 0.5 = 20\ \Omega$.
5. It remains constant.
6. Their physical conditions, such as temperature, change.

P3.2e — explain that for some resistors the value of R remains constant but that in others it can change as the current changes

1. Resistance does not change when the current changes, provided physical conditions remain constant.
2. An ohmic resistor.
3. It increases.
4. The filament gets hotter.
5. A diode allows current mainly in one direction and has much greater resistance in the other direction.
6. Its resistance changes as current or potential difference changes.

P3.2f — explain the design and use of circuits to explore such effects

1. Connect the wire to a power supply, ammeter and voltmeter and vary the current.
2. Ammeter.
3. Voltmeter.
4. Measure current and potential difference for different lengths of wire.
5. Measure current and potential difference at different temperatures.
6. Measure current and potential difference at different light intensities.

P3.2g — use graphs to explore whether circuit elements are linear or non-linear

1. An I-V graph.
2. A straight line through the origin.
3. Constant resistance.
4. Non-linear behaviour.
5. Check whether the graph is a straight line through the origin.
6. Current is directly proportional to potential difference.

P3.2h — use graphs and relate the curves produced to the function and properties of circuit elements

1. The relationship between current and potential difference.
2. The filament heats up, increasing its resistance.
3. It shows how current varies with potential difference and that current mainly flows in one direction.
4. The resistance is much lower in one direction than the other.
5. It decreases.
6. It decreases.

P3.2i — explain why, if two resistors are in series the net resistance is increased, whereas with two in parallel the net resistance is decreased

1. The resistances add.
2. It increases.
3. There are more paths for charge to flow.
4. It increases.
5. Series.
6. Charge has more than one path.

P3.2j — calculate the currents, potential differences and resistances in d.c. series and parallel circuits

1. $4 + 4 = 8\ \Omega$.
2. Total resistance = $6\ \Omega$; current = $12 \div 6 = 2$ A.
3. It divides equally between the branches.
4. $(6 \times 3) \div (6 + 3) = 2\ \Omega$.
5. Current = $12 \div 6 = 2$ A; p.d. = 4 V and 8 V.
6. $6 \div 3 = 2$ A.

P3.2k — explain the design and use of d.c. circuits for measurement and testing purposes

1. So the same current flows through the component.
2. So it measures the p.d. across the component.
3. So it does not significantly reduce the circuit current.
4. So it draws very little current.
5. Connect an ammeter in series and a voltmeter in parallel.
6. To obtain enough data to identify the relationship.

P3.2l — explain how the power transfer in any circuit device is related to the potential difference across it and the current, and to the energy changes over a given time

1. P = V × I.
2. Watt (W).
3. E = P × t.
4. 12 × 2 = 24 W.
5. 60 × 30 = 1800 J.
6. More energy is transferred.

P3.2m — apply the equations relating potential difference, current, quantity of charge, resistance, power, energy, and time, and solve problems for circuits which include resistors in series, using the concept of equivalent resistance

1. V = I × R.
2. Q = I × t.
3. E = V × Q.
4. P = V × I.
5. Total resistance = 10 Ω; current = 20 ÷ 10 = 2 A.
6. p.d. = 12 V; charge = 60 C; energy = 720 J.

P3.3 Magnets and magnetic fields

P3.3a — describe the attraction and repulsion between unlike and like poles for permanent magnets

1. North and south.
2. They attract.
3. They repel.
4. North and south.
5. North-north or south-south.
6. Unlike poles have connected field lines; like poles have field lines that do not join.

P3.3b — describe the difference between permanent and induced magnets

1. A magnet that remains magnetised.
2. A material that becomes magnetised when placed in a magnetic field.
3. It loses most or all of its magnetism.

4. It remains magnetised.
5. The induced magnet develops an opposite pole nearby.
6. Steel can be permanently magnetised; iron can be temporarily magnetised.

P3.3c — describe the characteristics of the magnetic field of a magnet, showing how strength and direction change from one point to another

1. A region where a magnetic force acts.
2. The direction a north pole would move.
3. North to south.
4. Near the poles.
5. Closer lines mean a stronger field.
6. Place small compasses around the magnet and record their directions.

P3.3d — explain how the behaviour of a magnetic (dipping) compass is related to evidence that the core of the Earth must be magnetic

1. Earth's magnetic field.
2. It aligns with Earth's magnetic field.
3. Evidence that Earth has a magnetic field.
4. Its needle is itself a small magnet.
5. The core must contain magnetic material or produce a magnetic field.
6. A compass requires a magnetic field to align with.

P3.3e — describe how to show that a current can create a magnetic effect and describe the directions of the magnetic field around a conducting wire

1. The compass needle deflects.
2. A current produces a magnetic field.
3. Concentric circles.
4. The direction is given by the right-hand grip rule.
5. The magnetic field direction reverses.
6. Place compasses around the wire and observe their directions.

P3.3f — recall that the strength of the field depends on the current and the distance from the conductor

1. It increases.
2. It decreases.
3. Vary the current and observe the compass deflection.

4. Measure the field at different distances.
5. 1 cm.
6. The 5 A wire.

P3.3g — explain how solenoid arrangements can enhance the magnetic effect

1. A coil of wire with several turns.
2. It produces a magnetic field.
3. It increases the field strength.
4. It strengthens the magnetic field.
5. Place compasses around the solenoid and observe their directions.
6. The fields from the individual turns combine.

P3.3h — describe how a magnet and a current-carrying conductor exert a force on one another

1. It experiences a force.
2. Interaction between the magnetic field and the current.
3. The force reverses.
4. The force reverses.
5. The force remains in the same direction.
6. A current-carrying wire experiences a magnetic force.

P3.3i — show that Fleming's left-hand rule represents the relative orientations of the force, the current and the magnetic field

1. The directions of force, current and magnetic field.
2. First finger.
3. Second finger.
4. Thumb.
5. Position the three fingers at right angles to each other.
6. The force direction reverses.

P3.3j — apply the equation that links the force on a conductor to the magnetic flux density, the current and the length of conductor to calculate the forces involved

1. $F = B \times I \times L$.
2. Tesla (T).
3. $0.5 \times 3 \times 0.20 = 0.30$ N.
4. $1.6 \div (2 \times 0.4) = 2$ T.
5. $0.9 \div (0.3 \times 0.5) = 6$ A.

6. The force doubles.

P3.3k — explain how the force exerted from a magnet and a current-carrying conductor is used to cause rotation in electric motors

1. Interaction between the current and magnetic field.
2. They act in opposite directions on opposite sides of the coil, producing a turning effect.
3. It reverses.
4. To keep the turning effect in the same rotational direction.
5. It provides the magnetic field needed to produce the force.
6. Electrical energy is transferred into kinetic energy and thermal energy.

Topic P4: Waves and radioactivity

P4.1 Wave motion

P4.1a — describe wave motion in terms of amplitude, wavelength, frequency and period

1. Maximum displacement from equilibrium.
2. Distance between successive corresponding points on a wave.
3. Number of complete waves per second.
4. Time for one complete wave.
5. It is the maximum displacement.
6. Measure the time for several cycles and calculate frequency.

P4.1b — define wavelength and frequency

1. Distance between successive points in phase.
2. Metre (m).
3. Number of complete waves per second.
4. Hertz (Hz).
5. One complete wavelength.
6. 50 complete oscillations occur each second.

P4.1c — describe and apply the relationship between wavelength, frequency and wave velocity

1. $v = f \times \lambda$.

2. It decreases.
3. It increases.
4. 200 × 1.5 = 300 m/s.
5. 340 ÷ 170 = 2 m.
6. 12 ÷ 0.4 = 30 Hz.

P4.1d — apply formulae relating velocity, frequency and wavelength

1. $v = f \times \lambda$.
2. 5 × 0.80 = 4 m/s.
3. 20 ÷ 4 = 5 m.
4. 300 ÷ 2 = 150 Hz.
5. 2.5 × 0.40 = 1.0 m/s.
6. 340 ÷ 0.68 = 500 Hz.

P4.1e — describe differences between transverse and longitudinal waves

1. Vibrations are perpendicular to the direction of travel.
2. Vibrations are parallel to the direction of travel.
3. Perpendicular.
4. Parallel.
5. Compressions and rarefactions.
6. Move it side-to-side for transverse waves and push-pull for longitudinal waves.

P4.1f — describe how ripples on water surfaces are used to model transverse waves whilst sound waves in air are longitudinal waves, and how the speed of each may be measured

1. The water moves up and down while the wave travels horizontally.
2. Air particles vibrate parallel to the direction of wave travel.
3. Measure wavelength and frequency, then use $v = f \times \lambda$.
4. Measure the distance between successive wave crests.
5. Measure a known distance and the time taken for sound to travel it.
6. Frequency and wavelength.

P4.1g — describe evidence for the cases of ripples on water surfaces and for sound waves in air that it is the wave that travels and not the water or the air

1. They mainly oscillate around fixed positions.
2. A floating object moves up and down but does not travel with the wave.

3. They vibrate back and forth.
4. They oscillate rather than travelling with the wave.
5. The object oscillates while the ripple travels past.
6. Energy.

P4.2 The electromagnetic spectrum

P4.2a — recall that electromagnetic waves are transverse and are transmitted through space where they all have the same velocity

1. Transverse.
2. 3.0×10^8 m/s.
3. Yes.
4. They are perpendicular.
5. They do not require a medium.
6. They have the same speed.

P4.2b — explain that electromagnetic waves transfer energy from source to absorber

1. Energy.
2. It is transferred to the absorber.
3. The absorber gains thermal energy.
4. Sunlight transfers energy to Earth.
5. They do not require a medium.
6. The source and the processes producing the radiation.

P4.2c — apply the relationships between frequency and wavelength across the electromagnetic spectrum

1. $c = f \times \lambda$.
2. It decreases.
3. $3.0 \times 10^8 \div 6.0 \times 10^8 = 0.50$ m.
4. $3.0 \times 10^8 \div (2.0 \times 10^{-2}) = 1.5 \times 10^{10}$ Hz.
5. The wave with a wavelength of 10^{-6} m.
6. The wave with a frequency of 10^9 Hz.

P4.2d — describe the main groupings of the electromagnetic spectrum and that these groupings range from long to short wavelengths and from low to high frequencies

1. Radio, microwave, infrared, visible, ultraviolet, X-ray, gamma.

2. Gamma, X-ray, ultraviolet, visible, infrared, microwave, radio.
3. Radio waves.
4. Gamma rays.
5. Radio waves.
6. Gamma rays.

P4.2e — describe that our eyes can only detect a limited range of the electromagnetic spectrum

1. Visible light.
2. No.
3. No.
4. Their wavelengths are outside the visible range.
5. A small part of the electromagnetic spectrum.
6. It is only a very small range of the full electromagnetic spectrum.

P4.2f — recall that light is an electromagnetic wave

1. An electromagnetic transverse wave.
2. The visible region.
3. Yes.
4. 3.0 × 10^8 m/s.
5. Visible light is one part of the electromagnetic spectrum.
6. It does not require a medium.

P4.2g — give examples of some practical uses of electromagnetic waves in the radio, microwave, infrared, visible, ultraviolet, X-ray and gamma ray regions

1. Radio communication.
2. Satellite communication or cooking.
3. Thermal imaging.
4. Seeing or optical fibres.
5. Sterilising equipment.
6. X-rays for medical imaging; gamma rays for treating cancer.

P4.2h — describe how ultraviolet waves, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues

1. They can damage cells.
2. Sunburn and increased risk of skin cancer.
3. They can damage cells and DNA.
4. They can damage cells and DNA.

5. X-rays.
6. To reduce the risk of tissue damage.

P4.2i — recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits

1. By oscillating electrical charges in an aerial.
2. Rapid electrical oscillations.
3. Oscillating electrical currents.
4. Radio waves induce electrical oscillations in the aerial.
5. An alternating electrical signal is produced.
6. Information is encoded onto the oscillating signal.

P4.2j — recall that different substances may absorb, transmit, refract, or reflect electromagnetic waves in ways that vary with wavelength

1. They can absorb, transmit, reflect or refract them.
2. Energy is taken in by the material.
3. The waves pass through the material.
4. The waves bounce from the surface.
5. The waves change direction when entering a different medium.
6. Different wavelengths interact differently with the material.

P4.2k — explain how some effects are related to differences in the velocity of electromagnetic waves in different substances

1. It changes.
2. Its speed changes.
3. A change in direction as a wave enters a different medium.
4. Different parts of the wavefront change speed, causing it to change direction.
5. It bends towards the normal.
6. Different substances cause different changes in wave speed.

P4.3 Radioactivity

P4.3a — recall that atomic nuclei are composed of both protons and neutrons, that the nucleus of each element has a characteristic positive charge

1. Protons and neutrons.

2. Positive.
3. No charge.
4. It contains positively charged protons.
5. Its number of protons.
6. More protons means a greater positive nuclear charge.

P4.3b — recall that atoms of the same elements can differ in nuclear mass by having different numbers of neutrons

1. Atoms of the same element with different numbers of neutrons.
2. They have different numbers of neutrons.
3. Neutrons.
4. Number of protons.
5. They have the same number of protons.
6. More neutrons give a greater mass number.

P4.3c — use the conventional representation for nuclei to relate the differences between isotopes identities, charges and masses

1. Number of protons.
2. Number of protons + neutrons.
3. The element symbol.
4. 11 protons and 12 neutrons.
5. 17 protons and 18 neutrons.
6. They have the same atomic number but different mass numbers.

P4.3d — recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays

1. A nucleus that can undergo radioactive decay.
2. Two protons and two neutrons.
3. A high-speed electron emitted from a nucleus.
4. Electromagnetic radiation from the nucleus.
5. It emits radiation or particles.
6. Alpha, beta, neutron and gamma radiation.

P4.3e — relate the emission of alpha particles, beta particles, gamma radiation and neutrons to possible changes in the mass or the charge of the nucleus, or both

1. Decreases by 4.
2. Decreases by 2.

3. Increases by 1.
4. Neither changes.
5. Decreases by 1.
6. Gamma radiation.

P4.3f — use names and symbols of common nuclei and particles to write balanced equations that represent radioactive decay

1. An alpha particle: $^{4}_{2}He$.
2. A beta particle: $^{0}_{-1}e$.
3. $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$.
4. $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$.
5. Mass number and atomic number.
6. $^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + ^{4}_{2}He$.

P4.3g — balance equations representing the emission of alpha, beta or gamma radiations in terms of the masses, and charges of the atoms involved

1. The same.
2. The same.
3. $^{4}_{2}He$.
4. $^{0}_{-1}e$.
5. $^{0}_{0}\gamma$.
6. Check that both mass number and atomic number balance.

P4.3h — recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation and that atoms can become ions by loss of outer electrons

1. In energy levels or shells.
2. It moves to a higher energy level.
3. It emits electromagnetic radiation.
4. The removal of an electron from an atom.
5. By losing an electron.
6. It has more protons than electrons.

P4.3i — recall that changes in atoms and nuclei can also generate and absorb radiations over a wide frequency range

1. Electromagnetic radiation.
2. An electron absorbs the correct amount of energy.

3. Electromagnetic radiation.
4. Gamma rays.
5. Yes.
6. Gamma radiation comes from changes in the nucleus.

P4.3j — explain the concept of half-life and how this is related to the random nature of radioactive decay

1. The time taken for half the unstable nuclei to decay.
2. Individual nuclei decay unpredictably.
3. No.
4. Half remain undecayed.
5. Fewer unstable nuclei remain.
6. The large number of decays produces a predictable statistical pattern.

P4.3k — calculate the net decline, expressed as a ratio, during radioactive emission after a given (integral) number of half-lives

1. 1/2.
2. 1/4.
3. 1/8.
4. $800 \div 8 = 100$ Bq.
5. $64 \div 16 = 4$ g.
6. 1/32.

P4.3l — recall the differences in the penetration properties of alpha particles, beta particles and gamma rays

1. Gamma.
2. Alpha.
3. Beta.
4. Lead or thick concrete.
5. Alpha is less penetrating.
6. Beta is less penetrating.

P4.3m — recall the differences between contamination and irradiation effects and compare the hazards associated with these two

1. Radioactive material gets onto or into something.
2. Exposure to radiation from a source without radioactive material being transferred.
3. Contamination involves radioactive material; irradiation does not.

4. Radioactive material remains on or inside the person.
5. The exposure stops when the external source is removed.
6. Contamination can continue exposing the person after the source is gone.

Topic P5: Energy

P5.1 Work done

P5.1a — describe for situations where there are energy transfers in a system, that there is no net change to the total energy of a closed system

1. Energy cannot be created or destroyed.
2. It stays constant.
3. No.
4. It is transferred to the thermal energy store of the surroundings.
5. The total amount stays the same.
6. Energy is transferred between stores rather than destroyed.

P5.1b — describe all the changes involved in the way energy is stored when a system changes for common situations

1. Gravitational potential energy.
2. It is transferred to other energy stores.
3. It increases.
4. Mainly to the thermal energy store of the surroundings.
5. It increases.
6. It increases.

P5.1c — describe the changes in energy involved when a system is changed by heating, by work done by forces, and by work done when a current flows

1. It increases.
2. A greater temperature usually means a greater thermal energy store.
3. Energy is transferred mechanically.
4. Energy is transferred electrically.
5. Electrical energy is transferred to thermal energy.
6. Work done is equal to energy transferred.

P5.1d — make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes

1. $W = F \times d$.
2. $50 \times 4 = 200$ J.
3. $E = P \times t$.
4. $2 \times 3 = 6$ kWh.
5. $\Delta E = mc\Delta T$.
6. $2 \times 500 \times 10 = 10{,}000$ J.

P5.1e — calculate the amounts of energy associated with a moving body, a stretched spring and an object raised above ground level

1. E□ = $\frac{1}{2}mv^2$.
2. $\frac{1}{2} \times 2 \times 5^2 = 25$ J.
3. $E_e = \frac{1}{2}ke^2$.
4. $\frac{1}{2} \times 200 \times 0.10^2 = 1$ J.
5. E□ = mgh.
6. $5 \times 10 \times 3 = 150$ J.

P5.2a — describe, with examples, the process by which energy is dissipated, so that it is stored in less useful ways

1. Energy is transferred to less useful energy stores.
2. It becomes difficult to use for the intended purpose.
3. Kinetic energy is transferred to thermal energy.
4. Kinetic energy is transferred mainly to thermal energy.
5. Friction transferring kinetic energy to thermal energy.
6. Less input energy becomes useful energy.

P5.2b — describe how, in different domestic devices, energy is transferred from batteries or the a.c. from the mains

1. Chemical energy → electrical energy → light and thermal energy.
2. Electrical energy → thermal energy.
3. Kinetic energy.
4. Some energy is transferred to thermal energy and sound.
5. Electrical energy is transferred to thermal energy.
6. A battery supplies d.c.; mains electricity supplies a.c.

P5.2c — describe, with examples, the relationship between the power ratings for domestic electrical appliances and how this is linked to the changes in stored energy when they are in use

1. The rate at which it transfers energy.
2. It transfers energy faster.
3. The 2 kW kettle.
4. Higher power means a faster increase in thermal energy.
5. 3000 × 10 = 30,000 J.
6. It transfers energy at a greater rate.

P5.2d — calculate energy efficiency for any energy transfer

1. Efficiency = useful energy ÷ total input energy.
2. Multiply by 100.
3. 800 ÷ 1000 = 0.80, or 80%.
4. 3500 ÷ 5000 = 0.70, or 70%.
5. 0.75 × 2000 = 1500 J.
6. Efficiency decreases.

P5.2e — describe ways to increase efficiency

1. Increase the proportion of input energy transferred usefully.
2. It reduces friction.
3. It reduces unwanted thermal energy transfer.
4. Less energy is dissipated as thermal energy.
5. More energy remains available for the useful purpose.
6. Reduce unwanted energy transfers.

P5.2f — explain ways of reducing unwanted energy transfer through lubrication and thermal insulation

1. It reduces friction.
2. Less kinetic energy is transferred to thermal energy.
3. It reduces thermal energy transfer.
4. They transfer thermal energy slowly.
5. It reduces thermal energy transfer through the walls.
6. They reduce unwanted energy transfers.

P5.2g — describe how the rate of cooling is affected by the thickness and thermal conductivity of its walls

1. It decreases.

2. It decreases.
3. Energy has further to travel through the wall.
4. They transfer thermal energy less easily.
5. Thin, highly conductive walls.
6. Use model buildings with different wall thicknesses and measure temperature over time.

Topic P6: Global challenges

P6.1 Physics on the move

P6.1a — recall typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems

1. About 1.5 m/s.
2. About 3 m/s.
3. About 6 m/s.
4. About 340 m/s.
5. About 10 m/s.
6. For example, a car: about 30 m/s.

P6.1b — estimate the magnitudes of everyday accelerations

1. Rate of change of velocity.
2. About 10 m/s^2.
3. About 1 m/s^2.
4. About 1 m/s^2.
5. Use $a = \Delta v \div t$.
6. Gravity produces a much larger acceleration.

P6.1c — make calculations using ratios and proportional reasoning to convert units and to compute rates

1. 1000 m.
2. 3600 s.
3. 20 m/s.
4. 54 km/h.
5. $600 \div 40 = 15$ m/s.
6. $20 \times 30 = 600$ m.

P6.1d — explain methods of measuring human reaction times and recall typical results

1. Drop a ruler and measure the distance it falls before being caught.
2. The distance the ruler falls.
3. To reduce the effect of random variation.
4. Calculate a mean.
5. About 0.2 s.
6. Tiredness.

P6.1e — explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies

1. Distance travelled while the driver reacts.
2. Distance travelled while braking.
3. Thinking distance + braking distance.
4. Greater speed, tiredness, distraction or alcohol/drugs.
5. Greater speed, poor brakes, worn tyres or wet/icy roads.
6. It increases.

P6.1f — explain the dangers caused by large decelerations

1. Negative acceleration.
2. It produces large forces on passengers.
3. They increase the time over which the passenger stops.
4. They increase stopping time and reduce the force.
5. The force decreases.
6. They increase the time taken to stop and reduce the force.

P6.2 Powering Earth

P6.2a — describe the main energy sources available for use on Earth, compare the ways in which they are used and distinguish between renewable and non-renewable sources

1. Renewable sources are naturally replaced; non-renewable sources are finite.
2. Coal, oil and natural gas.
3. Nuclear fuel is finite and cannot be replaced quickly.
4. Solar, wind, hydroelectric and tidal energy.
5. Biofuel is fuel made from recently living material, so it can be replaced as new crops or plants grow.

6. Advantage: renewable sources do not run out. Disadvantage: some are intermittent and depend on weather conditions.

P6.2b — explain patterns and trends in the use of energy resources

1. Population growth, industrialisation and increased use of technology have increased energy demand.
2. The use of fossil fuels increased greatly after the Industrial Revolution.
3. Renewable energy use has increased because of concerns about climate change, fossil fuel supplies and pollution.
4. Cost, availability, technology, government policies, environmental concerns and energy demand.
5. Coal produces large amounts of carbon dioxide and other pollutants, so cleaner energy sources have increasingly replaced it.
6. They show how the amount or proportion of energy obtained from different resources changes over time.

P6.2c — recall that, in the national grid, electrical power is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic use

1. At very high voltages, up to about 400 kV.
2. High voltage allows the same power to be transmitted with a lower current, reducing energy losses.
3. At substations.
4. To provide a safer and suitable voltage for domestic appliances.
5. It decreases.
6. A.C. electricity.

P6.2d — recall that step-up and step-down transformers are used to change the potential difference as power is transferred from power stations

1. It increases the potential difference.
2. It decreases the potential difference.
3. At or near power stations, before long-distance transmission.
4. At substations, before electricity is supplied to homes.
5. To increase the voltage, reducing the current and therefore reducing energy losses in the cables.
6. To reduce the voltage to a suitable level for homes and other users.

P6.2e — explain how the national grid is an efficient way to transfer energy

1. For the same power, a higher potential difference means a lower current, so less energy is dissipated in the cables.
2. The current decreases.
3. Less current means less heating of the cables and therefore less energy loss.
4. The resistance of the cables causes electrical energy to be transferred to thermal energy.
5. A lower voltage requires a larger current for the same power, increasing energy losses in the cables.
6. It transmits electricity at high voltage and then uses transformers to reduce the voltage for local use.

P6.2f — recall that the domestic supply in the UK is a.c. at 50 Hz and about 230 volts

1. A.C.
2. 50 Hz.
3. About 230 V.
4. The current changes direction 50 times each second.
5. 50 cycles.
6. Period = 1 ÷ 50 = 0.020 s.

P6.2g — explain the difference between direct and alternating voltage

1. A voltage that maintains the same polarity.
2. A voltage that repeatedly changes polarity.
3. D.C. produces current in one direction; a.c. produces current that repeatedly changes direction.
4. A horizontal line showing a constant voltage.
5. The polarity repeatedly reverses.
6. A.C.

P6.2h — recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires

1. It carries the alternating potential difference from the supply to the appliance.
2. It provides the return path for current to the supply.
3. It provides a safety path for current if there is a fault.
4. About 230 V.
5. About 230 V.

6. Approximately 0 V.

P6.2i — explain that a live wire may be dangerous even when a switch in a mains circuit is open, and explain the dangers of providing any connection between the live wire and earth

1. The live wire is still connected to the mains supply, so it remains at a high potential difference.
2. Touching it can allow a dangerous current to pass through the body.
3. It can cause a very large current to flow, creating a risk of electric shock, overheating or fire.
4. A very large fault current can flow to earth.
5. Insulation prevents a person from coming into contact with the live conductor.
6. To prevent dangerous fault currents, electric shocks and possible fires.